

Interested?

IVSE

Technical Reports are available on the Improving Ventilation and Saving Energy Website:

<http://eetd.lbl.gov/ied/ivse>

More information on IEQ in schools is at:

<http://www.dhs.ca.gov/iaq>

LBNL has an entire website devoted to indoor environmental quality research:

<http://eetd.lbl.gov/ied>



This work was conducted in collaboration with Bard Manufacturing Company:

<http://www.bardhvac.com>



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Contact Information:
California Energy Commission
Brad Meister
<http://www.energy.ca.gov/pier/index.htm/>
Michael Apte Principal Investigator
mgapte@lbl.gov
LBNL



IMPROVING VENTILATION AND SAVING ENERGY: HVAC FOR RELOCATABLE CLASSROOMS



HVAC for High Performance Modular Classrooms

Can We Improve Modular Classrooms?

California schools use about 100,000 relocatable classrooms (RCs, often referred to as “portable” or “modular” classrooms). Many have poor indoor air quality and use more energy than they should. Problems include:

- poor ventilation
- noisy HVAC systems
- high indoor air organic compound levels
- poor energy efficiency

Teachers often refrain from operating existing HVAC system ventilation because it is too noisy. This leads to poor indoor air quality and possibly more absence and poorer learning conditions. Based on previous research we developed an improved heat pump air conditioning (IHPAC) system specification that would address these problems.

Bard Manufacturing Company worked with this specification and constructed a prototype IHPAC system. This system was extensively tested in an RC test-bed at LBNL. Ten IHPAC units were then placed in RCs in four northern and southern California schools and monitored for one year, compared against standard 10 SEER HPAC systems in matched RCs at each school site.

IEQ and Energy Use Monitoring

Air Quality

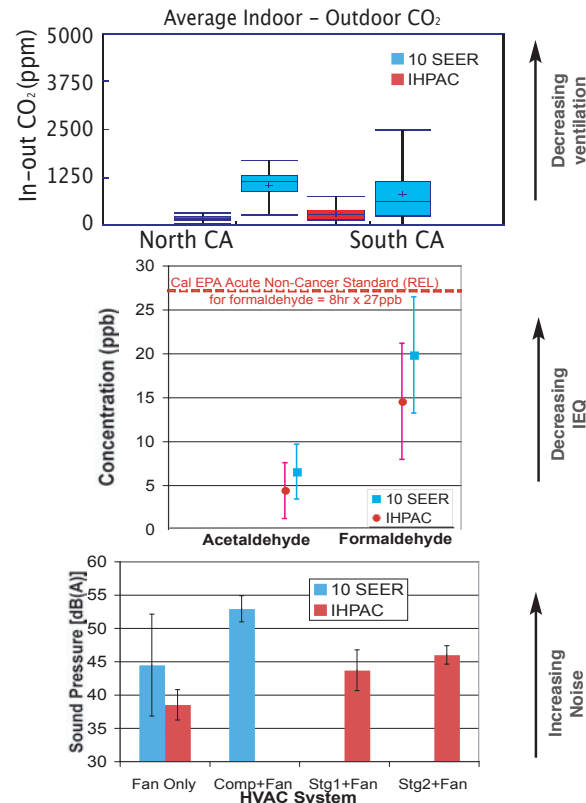
Carbon dioxide (I,O)
Particle number & size (I,O)
VOCs and aldehydes (I,O)
Thermal comfort (I)
Noise level (I)

Energy Monitoring

Temperature (I,O)
Relative humidity (I,O)
HVAC Energy

I = Indoors, O = Outdoors

The graphs shown below contain measured data from 10 RCs with IHPAC (red) and 6 with 10 SEER (blue) HVAC systems. These data are representative of those collected throughout the year of field study. More data are available upon request.



The IHPAC system significantly reduced noise vs. 10 SEER equipment - typical levels were below 45 dB(A). With an additional special IHPAC return air plenum sound levels were reduced to below 40 dB(A). The IHPAC controls provided continuous ventilation (480 CFM) during occupancy. 10 SEER RCs had variable ventilation depending upon how they were operated. Indoor-outdoor CO₂ concentrations were substantially lower in the IHPAC RCs reflecting the improved ventilation. Lower aldehyde concentrations and other measured volatile organic compounds were observed in the IHPAC RCs relative to the 10 SEER RCs. Thermal conditions were relatively similar in RCs with either system. Overall energy consumption was not reduced in the IHPAC RCs since the HVAC was used more frequently, and ventilation air requires energy to condition. Energy savings compared to 10 SEER RCs meeting ventilation requirements were significant.

Improved Heat Pump

Air Conditioner Specification

Noise Reduction

≤45 dB(A) @10 feet from the air return

Outside air supply

≥15 CFM/occupant for ≥32 occupants
(ASHRAE 62.1-2004)

Circulating fan power ≤0.17 KW

Controls

Continuous ventilation during occupancy irrespective of thermal demand.

Meet CA Title 24 pre-occupancy ventilation requirements of 3 air changes

Indoor CO₂ concentrations ≤600 ppm
above those outside (≥5 minutes)

Energy Efficiency

≥13.0 SEER or 9.8 EER and 14.0 IPLV
(Integrated Part Load Value) cooling &
3.2 COP heating efficiencies

Physical Package

Bolt-on replacement for standard wall-mount configuration

Thermal conditioning

Provide acceptable thermal comfort

Refrigerant

Use HCFC-free refrigerant anticipating 2010
HCFC refrigerant phase out



Bard's IHPAC (Patent Pending)